$$\varphi_F - \varphi_x = \alpha + \frac{\pi}{2}$$

$$tg(\alpha + \frac{\pi}{2}) = -\frac{1}{tg(\alpha)}$$

$$tg(\varphi_F - \varphi_x) = -\frac{1}{tg(\alpha)} = \frac{h\omega}{K - M\omega^2}$$

$$tg(\varphi_F - \varphi_x) = \frac{h\omega}{K - M\omega^2} = \frac{2\pi Nh}{K - M4\pi^2N^2}$$

4°)

a- $N_r = 20Hz$

b- Si $N \to 0$ alors $X_m = 10^{-2}m$

Si $N \to 0$ $X_m = 10^{-2}m$

Si $N = N_r$ $X_m = 10^{-1}m$

c- Pour $N = 0$ $X_m = 710m$

$\Rightarrow F_N = KX_m = 400 \times 710^{-2} = 28N$

5°)

a- $N_r^2 = N_0^2 - \frac{h^2}{8\pi^2M^2}$

$\Rightarrow h^2 = (N_0^2 - N_r^2)8\pi^2M^2$

$N_0 = \frac{1}{2\pi}\sqrt{\frac{k}{M}} = \frac{1}{2\pi}\sqrt{\frac{400}{20.10^{-3}}} = 22,5Hz$

$h = M\pi\sqrt{8(N_0^2 - N_r^2)} = 1,83\ Kg.s^{-1}$

b- $x(t) = x_m \sin(\omega_r t + \varphi_x)$

$\begin{cases} X_m = 10^{-1}m \\ \omega_r = 2\pi \times 20 = 40\pi\ rad.s^{-1} \end{cases}$

$tg(\varphi_F - \varphi_x) = \frac{2\pi N_r n}{k - 4\pi^2N_r^2.H} = 2,72$

$\Rightarrow \varphi_F - \varphi_x = 1,2 < \frac{\pi}{2}$

$x(t) = 10^{-1}\sin(40\pi t - 1,2)$

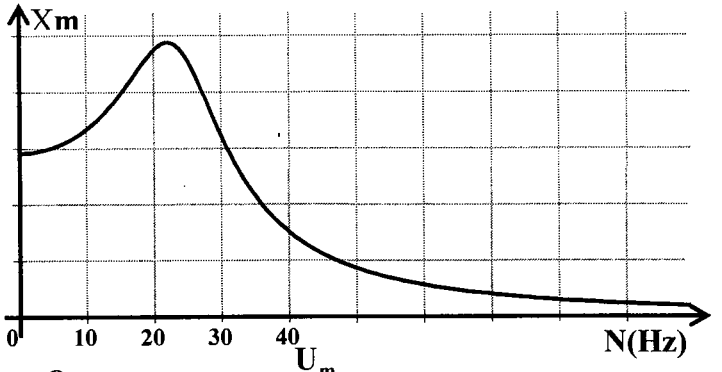
6°)

a- $N_r^2 > 0 \Rightarrow N_0^2 - \frac{h^2}{8\pi^2M^2} > 0$

$\Rightarrow N_0^2 > \frac{h^2}{8\pi^2M^2} \Rightarrow h^2 < 8\pi^2M^2N_0^2 \Rightarrow h < 2\sqrt{2}\pi MNo$

$\Rightarrow h_0 = 3,95(SI)$

b- $h_1 < h$



7°) $Q_m = \frac{U_m}{\sqrt{4\pi^2N^2R^2 + \left(4\pi^2N^2L - \frac{1}{C}\right)^2}}$